

Claims

1. A method of purifying a material, comprising:
melting solid material to form liquefied material;
directionally solidifying a portion of said liquefied material to convert said liquefied material to a combination of purified solidified material and liquid remainder;
removing said liquid remainder from said purified solidified material; and
melting said purified solidified material to form re-liquefied purified material.
2. A method as recited in claim 1, wherein said solid material comprises recycle scrap silicon and/or metallurgical grade silicon.
3. A method as recited in claim 1, further comprising at least one additional treatment cycle on said purified material, each said additional treatment cycle comprising directional solidification, liquid remainder removal and melting.
4. A method as recited in claim 1, wherein during said directional solidification, a solidification front travels from a bottom of said liquefied material substantially upward toward a top of said liquefied material at a rate of from about 0.1 cm/minute to about 0.2 cm/minute.
5. A method as recited in claim 1, wherein said solid material comprises at least about 95% by weight silicon.
6. A method as recited in claim 1, wherein said purified solidified material has a mass which is from about 85% to about 95% of a mass of said liquefied material.
7. A method as recited in claim 1, further comprising adding to said solid material at least one oxide additive and/or at least one nitride additive.
8. A method as recited in claim 7, wherein said oxide additive is silicon oxide and said nitride additive is silicon nitride.

9. A method as recited in claim 1, wherein said purified solidified material has a depth of not more than about 10 cm.

10. A method of purifying a material, comprising:
depositing solid material in a container;
melting said solid material to form liquefied material;
directionally solidifying a portion of said liquefied material to convert said liquefied material to a combination of purified solidified material and liquid remainder;
removing said liquid remainder from said container;
melting said purified solidified material to form re-liquefied purified material; and
removing said re-liquefied purified material from said container.

11. A method as recited in claim 10, wherein said solid material comprises recycle scrap silicon and/or metallurgical grade silicon.

12. A method as recited in claim 10, further comprising removing said re-liquefied purified material from said container.

13. A method as recited in claim 10, further comprising recycling said container and purifying at least one additional batch of solid material by depositing said additional batch of solid material in said container, melting said additional batch of solid material to form an additional batch of liquefied material, directionally solidifying a portion of said additional batch of liquefied material to form an additional batch of purified solidified material and an additional batch of liquid remainder, removing said additional batch of liquid remainder from said container, melting said additional batch of purified solidified material to form an additional batch of re-liquefied purified material; and removing said additional batch of re-liquefied material from said container.

14. A method as recited in claim 10, further comprising at least one additional treatment cycle on said purified material, each said additional treatment cycle comprising directional solidification, liquid remainder removal and re-melting.

15. A method as recited in claim 10, wherein during said directional solidification, a solidification front travels from a bottom of said liquefied material substantially upward toward a top of said liquefied material at a rate of from about 0.1 cm/minute to about 0.2 cm/minute.

16. A method as recited in claim 10, wherein said solid material comprises at least about 95% by weight silicon.

17. A method as recited in claim 10, wherein said purified solidified material has a mass which is from about 85% to about 95% of a mass of said liquefied material.

18. A method as recited in claim 10, further comprising adding to said solid material at least one oxide additive and/or at least one nitride additive.

19. A method as recited in claim 18, wherein said oxide additive is silicon oxide and said nitride additive is silicon nitride.

20. A method as recited in claim 10, wherein said purified solidified material has a depth of not more than about 10 cm.

21. A method of purifying a material, comprising:
melting solid material to form liquefied material, said solid material comprising at least 95% silicon or at least 95% germanium;
directionally solidifying a portion of said liquefied material to convert said liquefied material to a combination of purified solidified material and liquid remainder; and
removing said liquid remainder from said purified solidified material.

22. A method of purifying a material, comprising:
depositing solid material in each of a plurality of containers; and
moving each of said containers in sequence through positions where:

said solid material in each said container is melted to form liquefied material;

a portion of said liquefied material in each said container is directionally solidified to convert said liquefied material to a combination of purified solidified material and liquid remainder;

said liquid remainder in each said container is removed from said container;

said purified solidified material in each said container is melted to form re-liquefied purified material; and

said re-liquefied purified material in each said container is removed from said container.

23. A method as recited in claim 22, further comprising recycling each said container and purifying at least one additional batch of solid material in each said container by depositing said additional batch of solid material in each said container, melting said additional batch of solid material to form an additional batch of liquefied material, directionally solidifying a portion of said additional batch of liquefied material to form an additional batch of purified solidified material and an additional batch of liquid remainder, removing said additional batch of liquid remainder from each said container, melting said additional batch of purified solidified material to form an additional batch of re-liquefied purified material; and removing said additional batch of re-liquefied material from each said container.

24. A method as recited in claim 22, further comprising performing at least one additional treatment cycle on said purified material, each said additional treatment cycle comprising directional solidification, liquid remainder removal and re-melting.

25. A system for purifying a material, comprising:
at least one container;

a first melter which can create conditions under which a material being treated will melt to form a liquefied material;

a solidifier which can create conditions under which a part of said liquefied material will directionally solidify to convert said liquefied material to a combination of purified solidified material and liquid remainder;

a liquid remover which can remove said liquid remainder from said container; and

a second melter which can create conditions under which said purified solidified material melts to form a re-liquefied purified material.

26. A system as recited in claim 25, further comprising:

a material supplier which can supply material to said container; and

a second liquid remover which can remove said re-liquefied purified material from said container.

27. A system as recited in claim 25, wherein said liquid remover comprises a tipper which can tip said container to pour said liquid remainder out of said container.

28. A system as recited in claim 25, further comprising at least one radiation plate positioned such that during at least part of the time when said container is in said solidifier, said radiation plate will be between said solidifier and said container.

29. A system for purifying silicon and/or germanium, comprising:

at least one container;

a first heating zone which can create conditions under which silicon and/or germanium will melt to form a liquefied material;

a thermal treatment zone which can create conditions under which a part of said liquefied material will directionally solidify to convert said liquefied material to a combination of purified solidified material and liquid remainder;

a liquid remover which can remove said liquid remainder from said container; and

a second heating zone which can create conditions under which said purified solidified material melts to form a re-liquefied purified material.

30. A system as recited in claim 29, wherein said liquid remover comprises a tipper which can tip said container to pour said liquid remainder out of said container.

31. A system as recited in claim 29, wherein said thermal treatment zone comprises at least one cooling device and at least one radiation plate positioned where it will be between said cooling device and said container at least part of the time when said container is in said thermal treatment zone.